UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 6,707,529 B1
APPLICATION NO. : 09/913328
DATED : March 16, 2004
INVENTOR(S) : Aoki et al.

PLEASE SCAN ALL PAGES !!

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

PLEASE **DELETE** ENTIRE PATENT **TITLE PAGE, DRAWINGS** 1 THROUGH 10, AND **COLUMNS** 1 THROUGH 44

AND **INSERT TITLE PAGE, DRAWINGS** 1 THROUGH 4, AND **COLUMNS** 1 THROUGH 28 AS SHOWN ON THE ATTACHED PAGES.

CORRECTIONS HAVE BEEN MADE TO THE REPRINTED SPECIFICATION

Note This certificate supersedes certificate of correction issued October 23, 2007

~~Signed and Sealed this~~

~~Twenty-third Day of October, 2007~~

~~JON W. DUDAS~~
~~Director of the United States Patent and Trademark Office~~

US006707529B1

(12) **United States Patent**
Aoki et al.

(10) **Patent No.:** **US 6,707,529 B1**
(45) **Date of Patent:** **Mar. 16, 2004**

(54) **EXPOSURE METHOD AND APPARATUS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/913,328**

(22) PCT Filed: **Feb. 8, 2000**

(86) PCT No.: **PCT/JP00/00676**

§ 371 (c)(1), (2), (4) Date: **Oct. 15, 2001**

(87) PCT Pub. No.: **WO00/48237**

PCT Pub. Date: **Aug. 17, 2000**

(30) **Foreign Application Priority Data**

Feb. 12, 1999 (JP) 11/34897

(51) **Int. Cl.**^{7} **G03B 27/52**; G03B 27/42
(52) **U.S. Cl.** **355/30**; 355/53
(58) **Field of Search** 355/53, 67, 69–71, 355/30

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(57) **ABSTRACT**

An exposure apparatus having an illumination system which applies an exposure energy beam to a mask on which a pattern for transfer is formed, and a stage system for positioning a substrate to which the pattern of the mask is transferred, is characterized in that: a gas supply apparatus for supplying a gas of high transmittivity with respect to the exposure energy beam, and having good thermal conductivity, to at least a portion of an optical path of the exposure energy beam, and a gas recovery apparatus for recovering at least a portion of the gas after the gas is supplied to the optical path of the exposure energy beam from the gas supply apparatus, are provided.

44 Claims, 4 Drawing Sheets

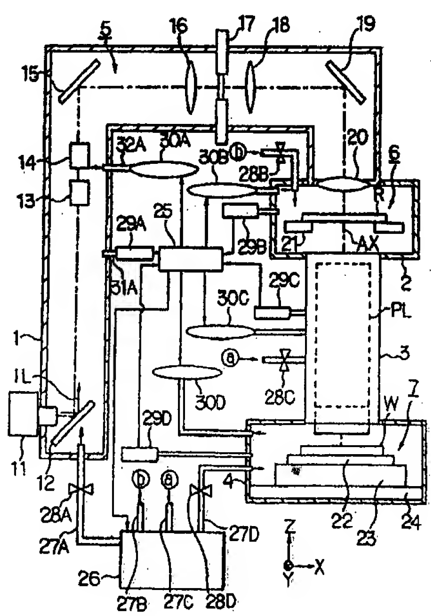

FIG. 1

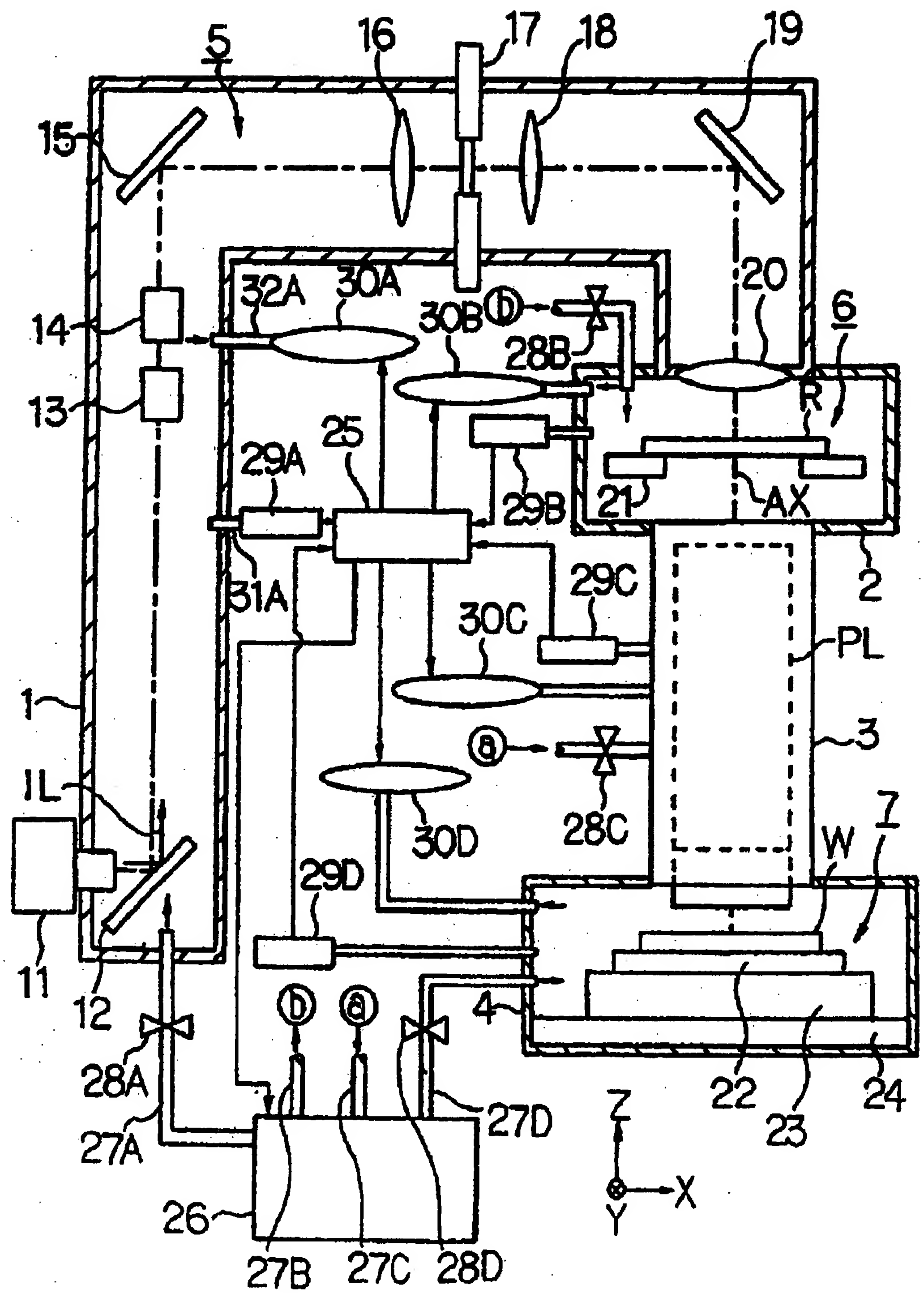
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FIG. 2

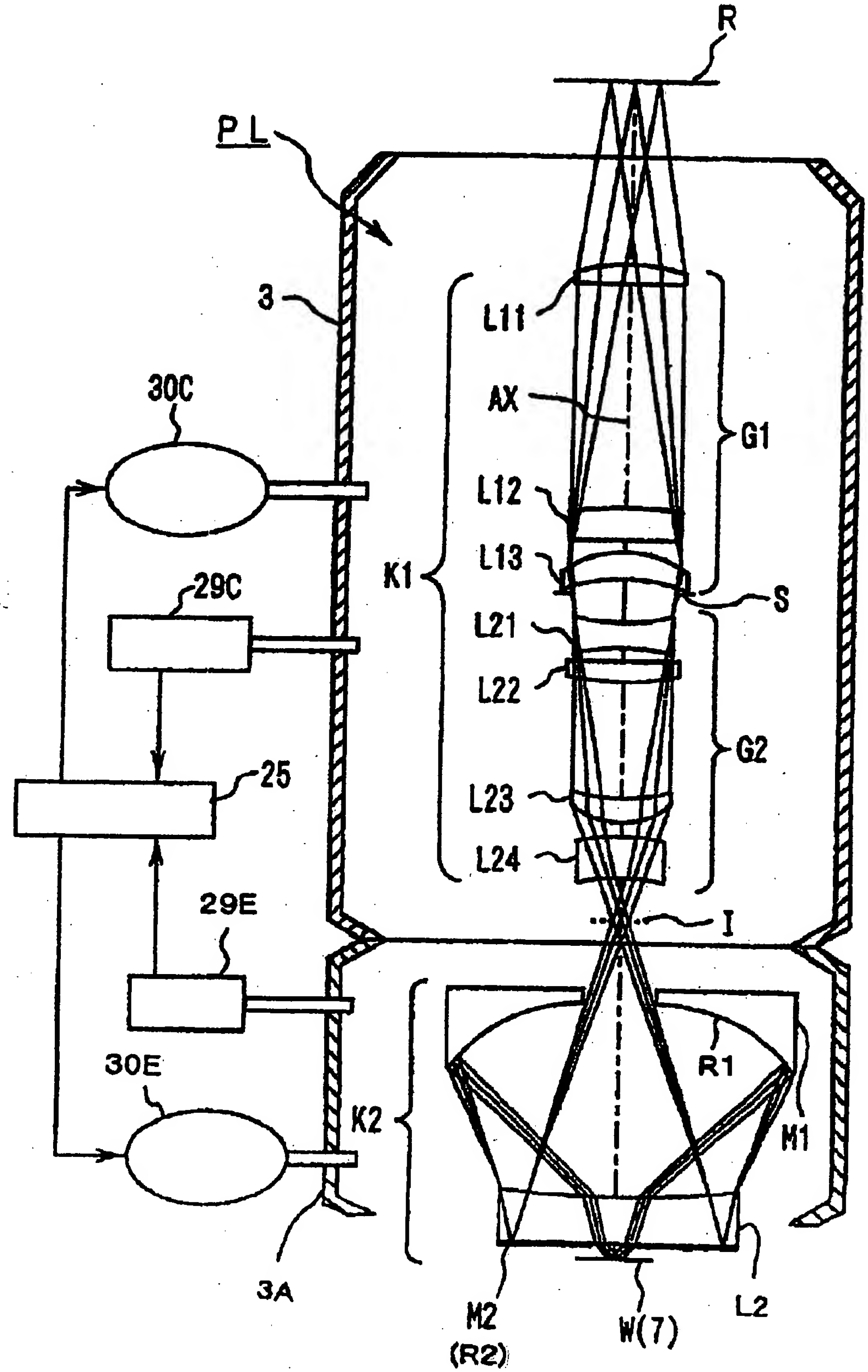
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FIG. 3

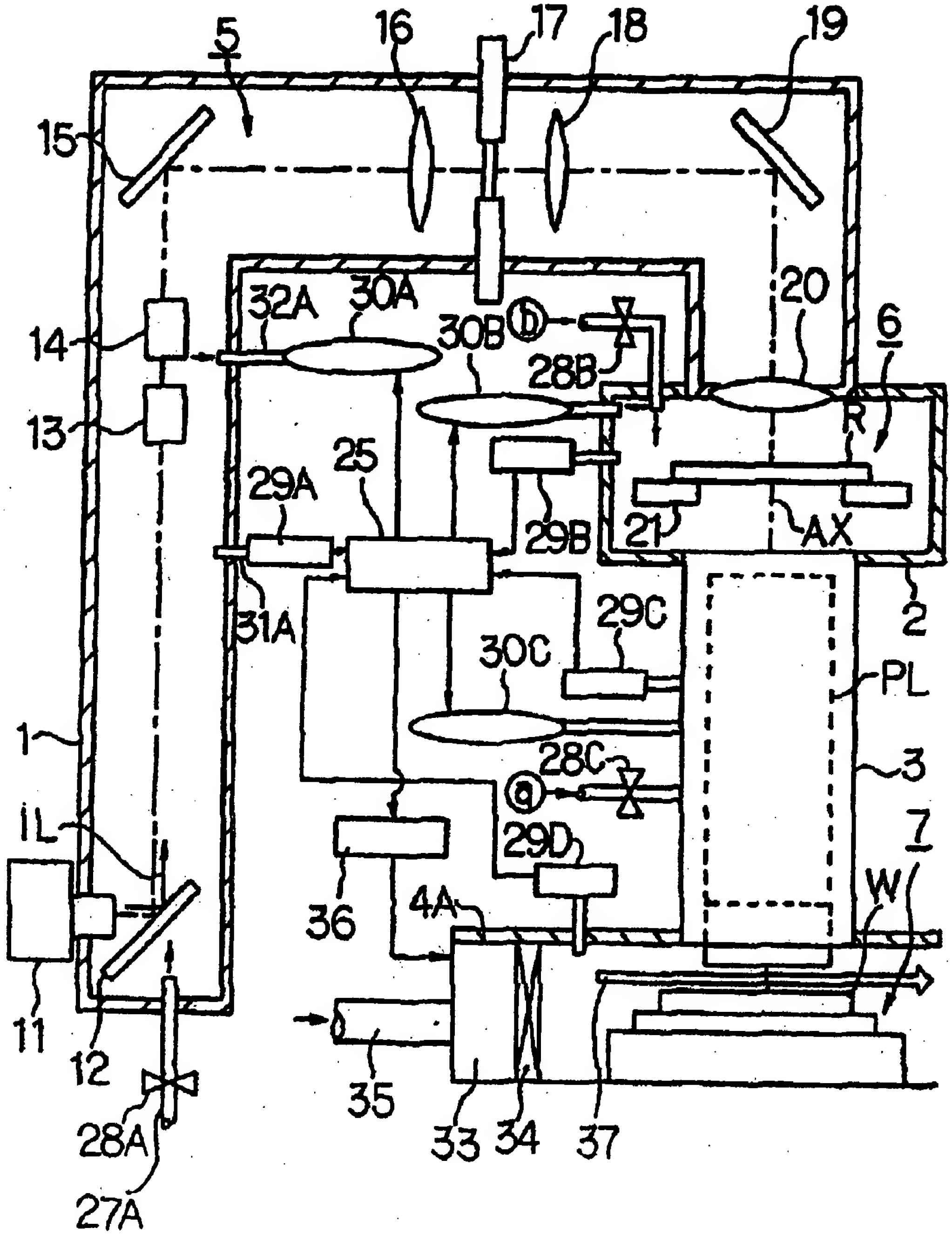
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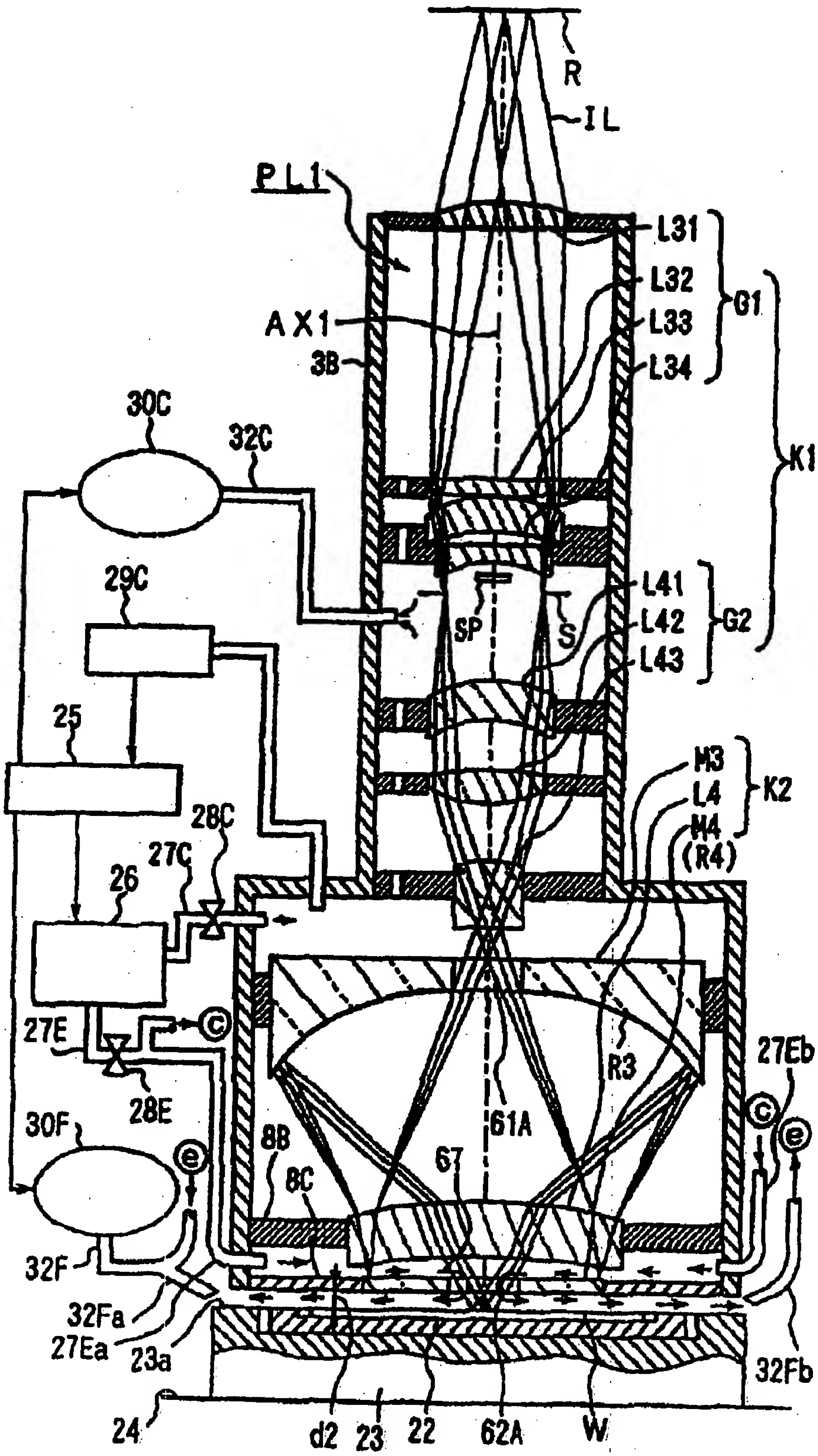
FIG. 4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30F
8B
61A
67
8C
32F
32Fa
27Ea
23a
32Fb
24
d2
23
22
62A
W

EXPOSURE METHOD AND APPARATUS

This application is the national phase under 35U.S.C. §371 of prior PCT International Application No. PCT/JP00/00676 which has an International filing date of Feb. 8, 2000 which designated the United States of America, the entire contents of which are hereby incorporated by reference.

DESCRIPTION

1. Technical Field

The present invention relates to an exposure method and apparatus to be used when a predetermined pattern is to be transferred onto a substrate in a lithographic process for manufacturing a semiconductor device, an image pick-up device (a CCD or the like), a liquid crystal display element, a thin film magnetic head or the like, for example, and more particularly, the present invention can be suitably used for a VUV light (Vacuum Ultraviolet light) having a wavelength of approximately 200 nm or less as an exposure beam.

2. Background Art

In the lithographic process for manufacturing a semiconductor device or the like, there have been used various exposure apparatuses such as a reducing projection type exposure apparatus, for example, a stepper, to transfer a reticle pattern to be a mask onto a wafer (or a glass plate or the like) coated with a resist (photosensitive material) to be a substrate, a proximity type exposure apparatus for directly transferring a reticle pattern on a wafer, and the like. In the exposure apparatus of this kind, conventionally, an ultraviolet light such as i rays of a mercury lamp (a wavelength of 365 nm) or a KrF excimer laser beam (a wavelength of 248 nm) has been used as an exposure beam (exposure light).

In order to obtain a higher resolution corresponding to an increase in integration of a semiconductor integrated circuit or the like, recently, the wavelength of the exposure beam has been more shortened. The practical use of the ArF excimer laser beam (a wavelength of 193 nm) has come to a final stage. An F_2 laser beam (a wavelength of 157 nm) has also been studied as an advanced exposure beam. On the other hand, a desired value of an energy (illuminance) of an exposure beam to be irradiated on a reticle (wafer) per unit time has been increased in order to enhance the throughput of the exposure apparatus. Referring to a dioptric member such as a lens in an illuminating optical system or a projecting optical system, synthetic silica glass, fluorite or the like having a high transmittance to a light having a wavelength of approximately 200 nm has been used.

As the exposure beam for the exposure apparatus, recently, the utilization of a vacuum ultraviolet light (VUV light) having a wavelength of approximately 200 nm or less has been investigated, and the use of a glass material having a high transmittance to the vacuum ultraviolet light has been investigated for the dioptric member in the illuminating optical system or the like. Referring to the exposure beam, however, a substance (hereinafter referred to as an absorption substance) for absorbing the exposed beam to greatly reduce the transmittance of the exposure beam is present in the atmosphere on an optical path in addition to the dioptric member. The absorption substance is varied depending on the wavelength of the exposure beam. In the normal air, ozone or the like acts as the absorption substance for a light having a wavelength of 200 nm or more, and oxygen molecules contained in the air, water molecules, carbon dioxide molecules and the like act as the absorption substances for the vacuum ultraviolet light.

In the case in which the air is supplied to the optical path of the vacuum ultraviolet light, therefore, the vacuum ultraviolet light is greatly absorbed by the absorption substances. For this reason, it is hard to cause the vacuum ultraviolet light to reach a wafer through a reticle with a sufficient illuminance. In order to prevent the illuminance on the wafer from being reduced, it is necessary to decrease the amount of the absorption substance on the optical path of the exposure beam or to eliminate the absorption substance, thereby increasing the transmittance of the optical path. For this purpose, there has been proposed a method of uniformly reducing the amount of the absorption substance on all the optical paths of the exposure beam or eliminating the absorption substance, thereby collectively managing the absorption material. However, if the absorption substance is collectively managed including the vicinity of a movable portion such as a reticle stage or a wafer stage and the inner portion of the illuminating optical system and the like, a mechanism might become complicated partially to increase the manufacturing cost of the exposure apparatus and the running cost of the exposure apparatus.

In consideration of such a respect, it is a first object to provide an exposure method capable of increasing the illuminance of an exposure beam on a transfer object.

Moreover, it is a second object of the present invention to provide an exposure method capable of increasing the illuminance of an exposure beam on a transfer object in the case in which an exposure beam capable of being easily absorbed by various substances, for example, a vacuum violet light is to be used. In particular, it is an object of the present invention to provide an exposure method capable of increasing the illuminance of an exposure beam on a transfer object without wholly complicating a mechanism or greatly increasing the running cost.

Furthermore, it is an object of the present invention to provide an exposure apparatus capable of carrying out the exposure method and a method of manufacturing a device using the exposure method.

DISCLOSURE OF THE INVENTION

The present invention provides a first exposure method which transfers a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, wherein an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths and concentrations of an absorption substance which absorbs the exposure beam are respectively managed independently of each other for the plurality of the partial optical paths.

According to the above-mentioned present invention, the optical path of the exposure beam is divided into a first partial optical path including an optical path of an illuminating optical system and a second partial optical path, which is located in the vicinity of a movable member such as a stage system, into which not only the outside air but also an absorption substance absorbing the exposure beam is easily mixed, but which has a shorter optical path length than the first partial optical path, for example. As compared with the first partial optical path, for example, the allowable concentration of the absorption substance contained in the second partial optical path is allowed to be increased, and by managing the concentration of the absorption substance in the first partial optical path and the second partial optical path independently of each other by eliminating the absorption substance and the like, the illuminance of the exposure beam (a pulse energy in the case of a pulse light) on the substrate can be increased without greatly complicating a mechanism such as a closing mechanism (an airtight

mechanism) of each partial optical path or an eliminating mechanism for the absorption substance.

In place of the concentration of the absorption substance, the total amount of the absorption substance in the partial optical path may be managed.

Furthermore, the present invention provides a second exposure method which irradiates an exposure beam from an exposure light source onto a mask through an illumination system and transfers a pattern of the mask onto a substrate through a projecting optical system, wherein an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths including an illumination system portion in the illumination system, a mask operating portion provided around the mask, a projecting optical system portion including at least a part of the projecting optical system and a substrate operating portion including an upper portion of the substrate, and concentrations of an absorption substance which absorbs the exposure beam are respectively managed independently of each other for the plurality of the partial optical paths.

According to the above-mentioned present invention, the outside air (absorption substance) is comparatively less mixed in the illumination system portion. Moreover, the mask operating portion has more movable portions to exchange and to position a mask and therefore the outside air is easily mixed therein. The projecting optical system portion has an almost closed structure and the substrate operating portion has more movable portions to exchange and to position a substrate. Moreover, the illumination system portion and the projecting optical system portion have longer optical path lengths than the optical path length of the mask operating portion or the substrate operating portion, and a fluctuation in the amount of each component in the atmosphere on the optical path is small, while the mask operating portion and the substrate operating portion have shorter optical path lengths than the optical path length of the illuminating optical system portion or the projecting optical system portion and the fluctuation in the amount of each component in the atmosphere on the optical path is great. As an example, a sealing property is enhanced for these partial optical paths, the flow of the absorption substance from the outside is almost blocked and the concentration of the absorption substance in the inner portion is managed independently for each partial optical path.

In order to reduce or eliminate the absorption substance on each partial optical path, for example, the allowable concentrations of the absorption substance are independently set for every partial optical path. In this case, the optical path is short in the mask operating portion and the substrate operating portion. As one of control methods, therefore, the allowable concentration of the absorption substance is allowed to be higher than that of other portions. In the partial optical path in which the concentration of the absorption substance exceeds the allowable concentration, exhaust (or pressure reduction) is carried out in the inner portion thereof. If necessary, then, a gas having a low absorptivity (a high transmittance) to the exposure beam is supplied to the inner portion, for example. Consequently, the concentration of the absorption substance is managed to be equal to or lower than the allowable concentration set for each partial optical path and the illuminance of the exposure beam on the substrate can be enhanced. Consequently, the mask pattern can be transferred onto the substrate with high precision and high throughput. In this case, particularly, the structures of the mask operating portion and the substrate operating portion can be relatively simplified as compared with the case in which the concentration of the absorption substance is collectively managed in the whole optical path.

Furthermore, the concentration of the absorption substance is allowed to be increased in the mask operating portion and the substrate operating portion and the concentration (or the total amount) of the absorption substance is managed independently of other illumination system portions and projecting optical system portions. Consequently, the illuminance of the exposure beam can be increased without complicating a control mechanism in the illumination system portion and the projecting optical system portion. In other words, in the case in which the concentration (amount) of the absorption substance in each of the mask operating portion and the substrate operating portion is increased and in such a situation that the degree of sealing is enhanced for each partial optical path, the mask operating portion and the substrate operating portion take countermeasures independently of other portions to solve the problems (the concentration is managed to reduce the concentration of the absorption substance). Consequently, the other portions are not affected by an increase in the concentration (amount) of the absorption substance. In the other portions, therefore, the concentration can easily be managed and the running cost can also be reduced. On the other hand, in the case in which the degree of sealing is not increased for each partial optical path and the concentration on the whole optical path is collectively managed, the other portions are adversely influenced when the concentration is increased in a part of the optical path.

In this case, when the exposure beam is a light in a vacuum violet region, an example of the absorption substance includes oxygen, water or carbon dioxide and an example of a gas having a high transmittance is nitrogen and a rare gas such helium, neon or argon or a mixed gas combining them.

The present invention provides a third exposure method which transfers a predetermined pattern onto a substrate by using an exposure beam transmitted from an exposure light source, wherein an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths and transmittances of the exposure beam are respectively managed independently of each other for the plurality of the partial optical paths. According to the present invention, for example, the degree of internal vacuum, the concentration (total amount) of a gas having a high transmittance in the inner portion, the concentration (total amount) of the absorption substance in the inner portion or the like is managed independently for the plurality of the partial optical paths. Consequently, it is possible to wholly simplify a mechanism, and furthermore, to efficiently increase the illuminance of (a pulse energy in the case of a pulse light) the exposure beam on the substrate.

The present invention provides a fourth exposure method which transfers a predetermined pattern onto a substrate by using an exposure beam transmitted from an exposure light source, wherein an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths and concentrations of a gas in the plurality of the partial optical paths are managed independently of each other. According to the present invention, in the case in which the gas, although having differences in extent for the exposure beam, acts as absorption substance, the concentrations of the gas are managed independently of each other so that the illuminance of the exposure beam can be increased on the substrate in the same manner as in the first exposure method.

In this case, the concentrations of the gas in the plurality of the partial optical paths may be managed depending on the lengths of the partial optical paths. Alternatively, the

concentrations of the gas may be managed depending on the frequencies of such as the in-and-out operation of the substrate between the partial optical path and the outside air. Examples of the gas of which concentrations are to be managed include nitrogen, helium, neon or argon or a mixed gas combining them.

The present invention provides a first exposure apparatus which transfers a predetermined pattern onto a substrate by using an exposure beam transmitted from an exposure light source, comprising a plurality of chambers which covers a plurality of partial optical paths formed by dividing an optical path of the exposure beam from the exposure light source to the substrate to substantially isolate the plurality of the partial optical paths from outside air, respectively, and a controller which manages concentrations of an absorption substance in the plurality of the chambers independently of each other. According to the present invention, the first exposure method can be carried out.

In this case, preferably, there are provided a concentration sensor which measures the concentrations of the absorption substance for absorbing the exposure beam in the plurality of the chambers and an eliminator which eliminates the absorption substance in the plurality of the chambers, and the controller manages the concentrations of the absorbtion substance through the eliminator according to the result of measurement of the concentration sensor.

In this case, furthermore, when the predetermined pattern is a pattern formed on a mask, the mask is illuminated by an illuminating optical system, a mask pattern is transferred onto the substrate through a projecting optical system, it is desirable that the plurality of the chambers include a first chamber which covers an illuminating system portion in an illuminating system for the exposure beam, a second chamber which covers a mask operating portion around the mask, a third chamber which covers a projecting optical system portion including at least a part of the projecting optical system, and a fourth chamber which covers a substrate operating portion including an upper portion of the substrate. With this, the second exposure method according to the present invention can be carried out. Moreover, the inner portions of the first to fourth chambers may be divided into a plurality of partial chambers which are isolated from each other.

The present invention provides a third exposure apparatus which transfers a predetermined pattern onto a substrate by using an exposure beam transmitted from an exposure light source, comprising a plurality of chambers which covers a plurality of partial optical paths formed by dividing an optical path of the exposure beam from the exposure light source to the substrate to be substantially isolate the plurality of the partial optical paths from outside air, respectively, and a controller which manages concentrations of a gas in the plurality of the chambers independently of each other. With this, the fourth exposure method according to the present invention can be carried out.

Moreover, the method of manufacturing a device according to the present invention comprises a step of transferring a predetermined pattern onto the substrate in such a state that an illuminance of an exposure beam is managed on the substrate by using the above-mentioned exposure methods according to the present invention. In this case, the illuminance of the exposure beam on the substrate is high. Therefore, it is possible to mass produce a semiconductor device or the like with high throughput.

BRIEF DESCRIPTION OF THE FIGURES IN THE DRAWINGS

FIG. 1 is a schematic view showing the structure of a projecting exposure apparatus according to an example of an embodiment in accordance with the present invention, a part of which is taken away.

FIG. 2 is a view showing an end face along a section according to an example of the structures of a projecting optical system PL and a barrel 3 in FIG. 1.

FIG. 3 is a schematic view showing the structure of a main part of a projecting exposure apparatus according to a second embodiment of the present invention, a part of which is taken away.

FIG. 4 is a view showing a structure from a projecting optical system PL1 to a wafer stage 23 according to a third embodiment of the present invention, a part of which is taken away.

BEST MODE FOR CARRYING OUT THE INVENTION

A preferred first embodiment of the present invention will be described below with reference to FIGS. 1 and 2. In the present embodiment, the present invention is applied to a projecting exposure apparatus of a step and scan type using a vacuum violet light as an exposure beam.

FIG. 1 is a view showing the schematic structure of the projecting exposure apparatus according to the present embodiment, a part of which is taken away. In FIG. 1, a mechanism portion of the projecting exposure apparatus according to the present embodiment is roughly divided into an illuminating optical system portion 5, a reticle operating portion 6, a projecting optical system PL and a wafer operating portion 7. Furthermore, the illuminating optical system portion 5, the reticle operating portion 6, the projecting optical system PL and the wafer operating portion 7 are accommodated in an illuminating system chamber 1, a reticle chamber 2, a barrel 3 and a wafer chamber 4 to be isolated from the outside air with a high degree of sealing, respectively. Furthermore, the projecting exposure apparatus according to the present embodiment is wholly accommodated in one large chamber in which the temperature of an internal gas (for example, purified air) is controlled into a predetermined target range.

In the illuminating optical system portion 5, first of all, an F_2 laser beam source for generating a pulse laser beam having a wavelength of 157 nm in a vacuum ultraviolet area is used as an exposure light source 11, and the emitting end of the exposure light source 11 is inserted into the lower side surface of the illuminating system chamber 1. During exposure, an illumination light IL (exposure beam) emitted from the exposure light source 11 into the illuminating system chamber 1 is reflected upward by a mirror 12 and is incident on a fly eye lens (or a rod lens) 14 to be an optical integrator (homogenizer) through an automatic following portion for aligning an optical axis shift caused by a vibration or the like which is not shown and a beam reshaping optical system 13 for reshaping the sectional shape of the illuminating system and controlling the amount of a light and an aperture diaphragm (not shown) is provided on the emitting surface of the fly eye lens 14 and an illumination light IL emitted from the fly eye lens 14 and passing through the aperture diaphragm is reflected in an almost horizontal direction through a mirror 15 and reaches a field stop (reticle blind) 17 through a relay lens 16.

A surface on which the field stop 17 is provided is almost conjugated with a pattern surface of a reticle R of an exposure object, and the field stop 17 includes a fixed blind for defining the shape of a slender and rectangular illumination region on the pattern surface and a movable blind for closing the illumination region to prevent exposure to an

unnecessary portion during the start and end of scanning and exposure. The illumination light IL passing through the field stop 17 illuminates, with a uniform illumination distribution, a rectangular (slit-shaped) illumination region on the pattern surface of the reticle R through a relay lens 18, a mirror 19 and a condenser lens system 20 fixed to the tip portion of the illuminating system chamber 1. The exposure light source 11 to the condenser lens system 20 constitute the illuminating optical system portion 5, and the optical path of the illumination light IL in the illuminating optical system portion 5, that is, the optical path from the exposure light source 11 to the condenser lens system 20 is closed by the illuminating system chamber 1.

Based on the illumination light IL, a pattern image in the illumination region of the reticle R is projected onto the wafer W coated with a photoresist to be a substrate with a projection magnification β (β is ¼, ⅕ or the like, for example) through the projecting optical system PL. The wafer (wafer) W is a disc-shaped substrate such as a semiconductor (silicon or the like), SOI (silicon on insulator) or the like, for example. In the case in which the illumination light IL is the F_2 laser beam as in the present embodiment, an optical glass member having a high transmittance is restricted to fluorite (CaF_2 crystal), quartz glass doped with fluorine, magnesium fluoride (MgF_2) or the like. Therefore, it is hard to obtain a desired image forming characteristic (color aberration characteristic or the like) by constituting the projecting optical system with only a dioptric member. The projecting optical system PL according to the present embodiment will be described by using a catadioptric system combining a dioptric member and a reflecting mirror as will be described below. In the case in which the desired imaging characteristic is to be obtained, the projecting optical system may be constituted by the dioptric system. A Z-axis is taken in parallel with an optical axis AX of the projecting optical system PL; an X-axis is taken in parallel with the paper of FIG. 1 in a plane perpendicular to the Z-axis (a horizontal plane in the present embodiment), and a Y-axis is taken perpendicularly to the paper in FIG. 1. The illumination region on the reticle R in the present embodiment is a slender rectangle in the X direction and the scanning direction of the reticle R and the wafer W during the exposure is set to be the Y direction.

At this time, the reticle R is held on a reticle stage 21. The reticle stage 21 continuously moves the reticle R in the Y direction on a reticle base which is not shown and slightly drives the reticle R to reduce a synchronization error in the X direction, the Y direction and the rotating direction. The position of the reticle stage 21 is measured with high precision by means of a laser interferometer which is not shown, and the reticle stage 21 is driven based on control information transmitted from a main control system 25 comprising a computer for generally controlling a measured value and the operation of the whole apparatus. The reticle operating operation 6 is constituted by the reticle, the reticle stage 21, a reticle base and a reticle loader which are not shown, and the like, and the optical path of the illumination light L in the reticle operating portion 6, that is, the optical path from the condenser lens system 20 to the projecting optical system PL is closed by the reticle chamber 2.

On the other hand, the wafer W is held on a wafer stage 23 through a wafer holder 22, and the wafer stage 23 continuously moves the wafer W in the Y direction over a wafer base 24 and moves the wafer W by stepping in the X direction and the Y direction. Moreover, the wafer stage 23 focuses the surface of the wafer W on the image plane of the projecting optical system PL by an autofocus method based on information about a position (a focus position) in an optical axis AX direction of the surface of the wafer W measured by an autofocus sensor which is not shown. The position of the wafer stage 23 is measured with high precision by means of a laser interferometer which is not shown, and the wafer stage 23 is driven based on a measured value and control information transmitted from the main control system 25.

During the exposure, an operation for stepping a shot area of an exposure object on the wafer W to this side in the exposure area of the projecting optical system PL and an operation for scanning the wafer W in the Y direction at a constant rate β·VR (β is a projection magnification of the projecting optical system PL) through the wafer stage 23 synchronously with the scanning of the reticle R at a constant rate VR in the Y direction for the illumination area of the illumination light IL through the reticle stage 21 are repeated by a step and scan method. Thus, the reduced image of a pattern of the reticle R is sequentially transferred into each shot area on the wafer W.

The wafer W, the wafer holder 22, the wafer stage 23, the wafer base and the wafer loader which are not shown and the like constitute the wafer operating portion 7, and the optical path of the illumination light IL in the wafer operating portion 7, that is, the optical path from the projecting optical system PL to the wafer W is closed by the wafer chamber 4. Moreover, the projecting optical system PL is closed and accommodated in the barrel 3, and the optical path from the optical member on the reticle side of the projecting optical system PL to the optical member on the wafer side is closed in the barrel 3.

The illumination light IL according to the present embodiment is a vacuum ultraviolet light having a wavelength of 157 nm. Therefore, an ordinary absorption substance in the air from which ozone for the illumination light IL is removed includes a gas such as oxygen (O_2) or carbon dioxide (CO_2), steam (H_2O) or the like. On the other hand, examples of a transmission gas to the illumination light IL (a substance rarely having absorption) include a rare gas such as helium (He), neon (Ne) or argon (Ar) in addition to a nitrogen gas (N_2). Moreover, while the nitrogen gas acts as the absorption substance for a light having a wavelength of approximately 150 nm or less, the helium gas can be used as a transmission gas with a wavelength of approximately 100 nm or less. Furthermore, the helium gas has a thermal conductivity which is approximately six times as high as that of the nitrogen gas and the amount of fluctuation in a refractive index for a change in an air pressure is approximately ⅛ of that of the nitrogen gas. For this reason, particularly, the helium gas has a high transmittance and is excellent in stability and cooling properties of an image forming characteristic of the optical system. However, the helium gas is expensive. Therefore, if the wavelength of the exposure beam is 150 nm or more as in the F_2 laser, the nitrogen gas may be use as a transmission gas in order to reduce the running cost. In the present embodiment, the nitrogen gas is used as the transmission gas for the illumination light IL.

As described above, a vacuum pump 30A for discharging a gas containing an internal absorption substance through a pipe 32A is connected into the illuminating system chamber 1. For example, the nitrogen gas to be a transmission gas to the illumination light IL is compressed with an impurity highly removed or liquefied and stored in a bomb of an air supply device 26 provided on the outside of a chamber (not shown) accommodating the whole projecting exposure apparatus according to the present embodiment. If

necessary, the nitrogen gas fetched from the bomb is controlled to a predetermined temperature at a predetermined pressure and is supplied into the illuminating system chamber 1 through a pipe 27A provided with a valve 28A which can be switched electromagnetically.

Moreover, a concentration sensor 29A for measuring the concentration of an absorption substance is connected into the illuminating system chamber 1 through a pipe 31A and the measured value of the concentration sensor 29A is supplied to the main control system 25. When the concentration of a predetermined absorption substance (oxygen, steam and carbon dioxide in the present embodiment) measured by the concentration sensor 29A exceeds a preset allowable concentration, the main control system 25 operates the vacuum pump 30A with the valve 28A closed and discharges the air and the absorption substance from the illuminating system chamber 1. Then, the main control system 25 opens the valve 28A and operates the gas supply device 26, and supplies a nitrogen gas having a high purity and a predetermined temperature at a predetermined pressure (usually, approximately 1 atm) into the illuminating system chamber 1 through the pipe 27A. Consequently, an air pressure in the illuminating system chamber 1 becomes substantially equal to that of the outside air. Then, the valve 28A is closed. The concentration of the absorption substance in the illuminating system chamber 1 is equal to or lower than the allowable concentration until a predetermined period of time passes from the operation.

Similarly, a nitrogen gas having a high purity is supplied from the gas supply device 26 to the reticle chamber 2, the barrel 3 and the wafer chamber 4 through a pipe 27B having an openable valve 28B, a pipe 27C having a valve 28C and a pipe 27D having a valve 28D at any time, and the concentration of the internal absorption substance is always measured by the concentration sensors 29B, 29C and 29D and a measured value is supplied to the main control system 25. Furthermore, vacuum pumps 30B, 30C and 30D are connected to the reticle chamber 2, the barrel 3 and the wafer chamber 4, respectively. When the concentration of the absorption substance measured by the concentration sensors 29B, 29C and 29D exceeds respective allowable concentrations, the main control system 25 operates the vacuum pumps 30B, 30C and 30D, the valves 28B to 28C and the air supply device 26 such that the concentrations of the absorption substances in the reticle chamber 2, the barrel 3 and the wafer chamber 4 can be maintained to be equal to or lower than the respective allowable concentrations. For the concentration sensors 29A to 29D, a complex sensor combining an oxygen analyzer, a hygrometer or a dew point meter to be a steam densitometer, a carbon dioxide sensor and the like can be used. For example, a polarography type oxygen analyzer, a zirconia and ceramics type oxygen analyzer, a white phosphorus emission type oxygen concentration sensor or the like can be used for the oxygen analyzer. For example, a crystal type hygrometer, an electric-resistance type hygrometer, infrared transmittance type hygrometer, a mirror reflectance measuring type dew point meter or the like can be used for the steam densitometer (the hydrometer or the dew point meter).

Moreover, a cryopump can be used for a vacuum pump. The cryopump has such a type as to utilize the fact that a vapor pressure of an element other than H_2, He and Ne is 10^{-8} Pa or less at 20K or less and a plane (cryopanel) cooled to a very low temperature (10 to 15K) is put in the vacuum and a gas (N_2, Ar, O_2, H_2O, CO_2 or the like) is adsorbed into the plane to create a clean vacuum.

Next, an example of the projecting optical system PL and the sealing mechanism according to the present embodiment will be described with reference to FIG. 2.

FIG. 2 is a view showing an end face along a section illustrating the internal structure of the projecting optical system PL in FIG. 1. In FIG. 2, the projecting optical system PL comprising a catadioptric optical system according to the present embodiment is constituted by a first imaging optical system K1 for forming a primary image (an intermediate image) I of the pattern of the reticle R and a second imaging optical system K2 for forming a secondary image of the reticle pattern on the wafer W to be a photosensitive substrate with a reduced magnification based on the light transmitted from the primary image I.

The first imaging optical system K1 is constituted by a first lens group G1 having a positive refractive power, an aperture diaphragm S and a second lens group G2 having a positive refractive power which are sequentially provided from the reticle side. The first lens group G1 is constituted by a positive meniscus lens L11 having a non-spherical convex turned toward the reticle side, a positive meniscus lens L12 having a non-spherical convex turned toward the reticle side, and a positive meniscus lens L13 having a non-spherical concave turned toward the wafer side which are sequentially provided from the reticle side.

Moreover, a second lens group G2 has a biconcave lens 21 having a plane on the reticle side to take a non-spherical shape, a biconvex lens L22 having a plane on the reticle side to take a non-spherical shape, a positive meniscus lens L23 having a non-spherical convex turned toward the wafer side, and a positive meniscus lens L24 having a non-spherical concave turned toward the wafer side which are sequentially provided from the reticle side.

On the other hand, the second imaging optical system K2 is constituted by a main mirror M1 including a surface reflection plane R1 having a concave turned toward the wafer side and an opening on a center, a lens component L2, and an auxiliary mirror M2 including a reflection plane R2 provided on a lens plane at the wafer side and having an opening on a center which are sequentially provided from the reticle side. In another respect, the auxiliary mirror M2 and the lens component L2 constitute a back-surface reflecting mirror, and the lens component L2 constitutes a refracting portion of the back-surface reflecting mirror. In this case, it is desirable that a relationship of $0.7<|\beta 1/\beta 2|<3.5$ should be satisfied as an example, wherein the imaging magnification of the first imaging optical system K1 is represented by $\beta 1$ and the imaging magnification of the second imaging optical system K2 is represented by $\beta 2$.

Moreover, all optical elements (G1, G2, M1, M2) constituting the projecting optical system PL are provided along a single optical axis AX. Furthermore, the main mirror M1 is provided in the vicinity of a position where the primary image I is to be formed and the auxiliary mirror M2 is provided in the proximity of the wafer W.

In the present embodiment, thus, the light transmitted from the pattern of the reticle R forms the primary image (intermediate image) I having a reticle pattern through the first imaging optical system K1 and the light transmitted from the primary image I is reflected by the main mirror M1 through the central opening of the main mirror M1 and the lens component L2. The light reflected by the main mirror M1 forms the secondary image of the reticle pattern with a reduced magnification on the surface of the wafer W through the lens component L2 and the central opening of the auxiliary mirror M2. In the example of FIG. 2, the imaging magnification $\beta 1$ of the first imaging optical system K1 is 0.6249, the imaging magnification $\beta 2$ of the first imaging optical system K2 is 0.4000 and a projecting magnification β from the reticle R to the wafer W is 0.25 (1.4 time as large).

In the present example, fluorite (CaF_2 crystal) is used for all the dioptric members (lens components) constituting the projecting optical system PL. Moreover, the F_2 laser beam to be the exposed laser has an oscillating central wavelength of 157.6 nm and a chromatic aberration is corrected for a light having a wavelength width of 156 nm±10 pm and various aberrations such as a spherical aberration, an astigmatism and a distortion aberration can also be corrected well. In order to prevent a change in the reflection plane of the main mirror M1 for a change in a temperature to maintain an excellent imaging performance, furthermore, a support member supporting a reflection plane S1 of the main mirror M is formed by using a substrate having a coefficient of linear expansion of 3 ppm/° C. or less, for example, titanium silicate glass. For the titanium silicate glass, ULE (trade name of Ultra Low Expansion) produced by Corning Co., Ltd. can be used, for example.

The projecting optical system PL according to the present embodiment has all the optical elements constituting the catadioptric system which are provided along a single optical axis. Therefore, the chromatic aberration or the like can be reduced by using a reflecting member, and furthermore, a barrel can be designed and manufactured by the advanced technique of a conventional direct cylinder type refraction system and the precision can be increased without the difficulty of the manufacture.

As an example of a first structure according to the present embodiment, the first imaging optical system K1 and the second imaging optical system K2 are enclosed and supported in the single barrel 3. In the second imaging optical system K2, the illumination light passes through a space plural times. Therefore, it is desirable that the concentration of the absorption substance should be managed to be lower more strictly.

For an example of a second structure, as shown in FIG. 2, each optical element of the first imaging optical system K1 is supported by a lens frame which is not shown in such a state as to be enclosed in the barrel 3 and the main mirror M1 and the auxiliary mirror M2 in the second imaging optical system K2 are enclosed and supported in another lower barrel 3A through a support member which is not shown, respectively. In this case, the portions in the barrel 3 and the lower barrel 3A through which the exposure beam passes may be sealed with a parallel flat glass formed of the material having a high transmittance described above, for example, which is not shown.

As described with reference to FIG. 1, moreover, the concentration sensor 29C and the vacuum pump 30C are connected to the barrel 3. Similarly, the concentration sensor 29E and the vacuum pump 30E are also connected to the lower barrel 3A. Furthermore, a nitrogen gas having a high purity can be supplied at any time from the air supply device 26 shown in FIG. 1 to the barrel 3 and the lower barrel 3A. The concentrations of the absorption substances in the barrel 3 and the lower barrel 3A are managed to be equal or lower than an allowable concentration during the exposure independently of each other through the main control system 25. In the example of the structure, the transmittance of the illumination light for the whole projecting optical system PL can be increased by setting the allowable concentration of the absorption substance in the lower barrel 3A to be lower than the allowable concentration in the barrel 3. In the following description, it is assumed that the projecting optical system PL is accommodated in one barrel 3.

Returning to FIG. 1, description will be given to an example of the whole managing operation for reducing an absorption substance on the optical path of an exposure beam in the projecting exposure apparatus according to the present embodiment.

First of all, the reticle chamber 2 is an important management object in the exposure apparatus using the exposure beam to be absorbed by ordinary air, particularly, a vacuum ultraviolet light. The reason is as follows. It is necessary to fetch an optional reticle from a reticle library provided on the outside of a space (reticle chamber 2) accommodating a reticle R to be an exposure object and managing the concentration of an absorption substance, to move the reticle into the space managing the absorption substance and to provide the reticle on the optical path of the illumination light IL to be the exposure beam. The reticle is varied for each semiconductor element for exposing or each layer for exposing. Therefore, the reticle is exchanged depending on a required step. Consequently, the reticle is exchanged with a high frequency. Accordingly, the reticle chamber 2 not only isolates the reticle R on the optical path from the outside of the space for managing the absorption substance but also efficiently discharges foreign matters (impurities) generated from the movable portion such as the reticle stage 21 or the reticle loader (not shown), and furthermore, functions to suppress an increase in the absorption substance on the optical path on the outside of the reticle chamber 2. It is apparent that the same role can also be applied to the wafer chamber 4.

It is desirable that a space in the reticle library and a delivery space between the reticle library and the reticle chamber should also manage the absorption substance in the same manner as the reticle chamber. Moreover, the inside of a wafer delivery space for delivering a wafer to the wafer chamber may also manage the absorption substance in the same manner as the wafer chamber.

As is apparent from FIG. 1, next, the optical lengths of the illumination light IL in the optical paths (hereinafter referred to as "partial optical paths") in the illuminating system chamber 1, the reticle chamber 2, the barrel 3 and the wafer chamber 4 which accommodate each portion of the projecting exposure apparatus are different from each other, and the illuminating optical system portion 5 in the illuminating system chamber 1 has the greatest optical length and the projecting optical system PL in the barrel 3 has the second greatest optical path. The amount of the absorption substance through which the illumination light IL passes is proportional to the optical path length in the case in which the concentration of the absorption substance is constant. Therefore, the amounts of a reduction in the illuminance are different from each other in the four partial optical paths. For this reason, it is desirable that the optical path having a longer optical path length should have a smaller amount of the absorption substance. Moreover, the illuminating optical system portion 5 having a long optical path and the projecting optical system PL can have a closed structure comparatively easily. Basically, it is possible to prevent the absorption substance from flowing from the outside. Moreover, since the illuminating optical system portion 5 and the projecting optical system PL have few movable portions, the absorption substance can easily be managed at a lower concentration. Accordingly, it is possible to reduce a drop in the illuminance in the illuminating optical system portion 5 and the projecting optical system PL by once reducing the concentration of the absorption substance in the illuminating system chamber 1 and the barrel 3 and maintaining the same state.

Moreover, the optical lengths in the reticle chamber 2 and the wafer chamber 4 are shorter than those of the illuminat-

ing optical system 5 and the projecting optical system PL. However, these spaces are such that parts such as a reticle or a wafer are taken from and to the outside at any time during the actuation of the projecting exposure apparatus. At each time, the parts are exposed to the flow of air, an impurity or the like from the outside, and some foreign matters are discharged from the movable portion. Consequently, the concentration of the absorption substance cannot be easily maintained to be low. In the present embodiment, the allowable concentration of the absorption substance in each partial optical path is set such that the allowable absorptivity (allowable absorbance) of the illumination light IL is constant in each partial optical path from the illuminating system chamber 1 to the wafer chamber 4. As a result, the allowable concentration of the absorption substance is set to be higher on the partial paths in the reticle chamber 2 and the wafer chamber 4 than the allowable concentration on other partial optical paths and they contribute to a whole reduction in the illuminance of the illumination light IL almost equivalently. By this method, in addition, the drop in the illuminance can be reduced at a low running cost more actually and the apparatus does not need to be complicated.

There will be described examples of the allowable concentrations of oxygen, carbon dioxide and steam to be absorption substances from the illuminating system chamber 1 to the wafer chamber 4. In this case, the optical path lengths of the partial optical paths in the illuminating system chamber 1, the reticle chamber 2, the barrel 3 of the projecting optical system PL and the wafer chamber 4 are as follows.

Optical path length in the illuminating system chamber 1: 5000 mm

Optical path length in the reticle chamber 2: 200 mm

Optical path length in the barrel 3: 1350 mm

Optical path length in the wafer chamber 4: 10 mm

If the allowance absorptivity in the partial optical length is 1%, the allowable concentrations of oxygen (O_2), carbon dioxide (CO_2) and steam (H_2O) in each partial optical path are shown in the following Table 1.

TABLE 1

	Allowable O_2 concentration (ppm)	Allowable CO_2 concentration (ppm)	Allowable H_2O concentration (ppm)
Illuminating system chamber 1	6.7×10^{-2}	3.3	2.3×10^{-1}
Reticle chamber 2	1.7	8.2×10^{1}	6.8
Barrel 3	2.5×10^{-1}	1.2×10^{1}	1.0
Wafer chamber 4	3.4×10^{1}	1.7×10^{3}	1.37×10^{2}

If the allowance absorptivity in the partial optical length is 5%, the allowable concentrations of oxygen (O_2), carbon dioxide (CO_2) and steam (H_2O) in each partial optical path are shown in the following Table 2.

TABLE 2

	Allowable O_2 concentration (ppm)	Allowable CO_2 concentration (ppm)	Allowable H_2O concentration (ppm)
Illuminating system chamber 1	3.4×10^{-1}	1.7×10^{1}	1.4
Reticle chamber 2	8.6	4.2×10^{2}	3.5×10^{1}

TABLE 2-continued

	Allowable O_2 concentration (ppm)	Allowable CO_2 concentration (ppm)	Allowable H_2O concentration (ppm)
Barrel 3	1.3	6.2×10^{1}	5.1
Wafer chamber 4	1.7×10^{2}	8.4×10^{3}	6.9×10^{2}

From the Tables 1 and 2, it is apparent that the allowable concentration of the absorption substance in each of the reticle chamber 2 and the wafer chamber 4 is 10 to 100 times as high as that in each of the illuminating system chamber 1 and the barrel 3. Consequently, the concentration of the absorption substance in each of the reticle chamber 2 and the wafer chamber 4 can be managed easily and the mechanism for the reticle chamber 2 and the wafer chamber 4 do not need to be complicated.

Next, the projecting exposure apparatus according to the present embodiment uses a step and scan method. Therefore, a movable portion for synchronously scanning a reticle and a wafer is provided in the reticle chamber 2 and the wafer chamber 4. As described above, moreover, a contact with the outside air and the mixture of the absorption substance cannot be avoided because of the exchange of the reticle and the wafer. Therefore, it is necessary to operate the vacuum pumps 30B and 30D and the air supply device 26 to discharge the absorption substance until the concentration of the absorption substance in each of the reticle chamber 2 and the wafer chamber 4 is set to be equal to or lower than the allowable concentration after the reticle and the wafer are scanned and exposed or are exchanged. In the meantime, it is apparent that the circuit pattern of the reticle is not exposed.

It is preferable that pressure reduction should be carried out in the space for managing the concentration of the absorption substance (in the illuminating system chamber 1 to the wafer chamber 4) through the vacuum pumps 30A to 30D, respectively. Then, a gas which rarely absorbs the illumination light is supplied from the gas supply device 26 so that the absorption substance can be reduced or eliminated efficiently. In this case, no difference in an air pressure between the inside of each of the illuminating system chamber 1 to the wafer chamber 4 and the outside air can be substantially considered to be made. Therefore, it is not necessary to cause each portion of the exposure apparatus to be a redundant mechanism having an unnecessary strength. In the illuminating system chamber 1 to the wafer chamber 4, the absorption substance may be eliminated to carry out the exposure in an almost vacuum state. In this case, it is necessary to increase the strength of each portion of the exposure apparatus. However, it is possible to maintain the illuminance to be extremely high without depending on the wavelength of the illumination light.

It is not necessary to always carry out the pressure reduction in the illuminating system chamber 1 to the wafer chamber 4 to obtain a high vacuum. More specifically, the degree of vacuum during the pressure reduction depends on the density (amount) of the absorption substance present in the atmosphere and the optical path length in the atmosphere. If the allowable absorptivity of the exposed light to be absorbed by an optical path length of 1 m in the air atmosphere is set to 1%, it is preferable that the pressure reduction should be carried out to approximately 1.2×10^{-3} Torr. If the allowable absorptivity of the exposed light to be absorbed by an optical path length of 1 m in the air atmosphere is set to 3%, it is preferable that the pressure

reduction should be carried out to approximately 3.8×10^{-3} Torr. When a substance having a higher coefficient of absorption is present in the atmosphere, it is sufficient that the pressure reduction is carried out to a higher degree of vacuum. When only a substance having a smaller coefficient of absorption is present in the atmosphere, it is sufficient that the pressure reduction is carried out to a lower degree of vacuum.

Moreover, the inside of each of the illuminating system chamber **1** to the wafer chamber **4** according to the present embodiment is closed. By supplying another gas (hereinafter referred to as a "purging gas") for rarely absorbing the illumination light to the respective spaces through which the exposure beam passes and discharging a mixed gas of the purging gas and the absorption substance without using a vacuum pump, therefore, the concentration (amount) of the absorption substance may be reduced to a predetermined value or less and a reduction in the illumination in each inner portion may be prevented. In this case, for example, purging may be carried out with an inexpensive gas (a nitrogen gas or the like) in a portion having a small optical length (the volume of a space for managing the concentration of the absorption substance including the optical path is small), and the purging may be carried out with a slightly expensive helium gas or the like in a portion having a great optical path length (the volume of a space for managing the concentration of the absorption substance including the optical path is great). For example, consequently, the stability of a temperature control characteristic and an imaging characteristic and the like can be enhanced without greatly raising the running cost.

In the portion having a small optical length, moreover, the nitrogen gas may be supplied to all the partial optical paths. In the portion having a great optical length, the nitrogen gas or the helium gas may be supplied to all the partial optical paths irrespective of the optical path length separately from such a structure that the helium gas is used. Moreover, the helium gas may be supplied to the portion having a small optical path length and the nitrogen gas may be supplied to the portion having a great optical path length. Also in the case in which an expensive gas (the helium gas or the like) is supplied to a portion having a high degree of sealing (airtightness) and an inexpensive gas (the nitrogen gas or the like) is supplied to a portion having a low degree of sealing (in which an absorption substance is easily mixed), the running cost can be reduced.

Next, a preferred second embodiment of the present invention will be described with reference to FIG. **3**. While a structure in the present embodiment is basically the same as that of the first embodiment, the present embodiment is different from the first embodiment in that a portion corresponding to the wafer chamber **4** in FIG. **1** is not closed and there is no structure in which a wafer opening portion **7** is isolated from the outside air, that is, the atmosphere in a great chamber accommodating a projecting exposure apparatus. In FIG. 3, portions corresponding to those in FIG. 1 have the same reference numerals and detailed description thereof will be omitted.

FIG. 3 shows the main part of the projecting exposure apparatus according to the present embodiment. In FIG. 3, the upper part of the wafer operating portion 7 is covered with a cover 4A to cover the side surface of a projecting optical system PL. A blast portion 33 and a filter portion 34 are provided in the direction of the side surface of the wafer operation portion 7, and the temperature of a transmission gas (a nitrogen gas, a helium gas or the like, for example) to an illmination light IL is controlled and is supplied from an air supply device which is not shown to the blast portion **33** through a pipe **35**. As shown in an arrow **37**, the blast portion **33** feeds a gas in a flow corresponding to control information sent from a main control system **25** around the wafer operating portion **7** under the cover **4A** through the filter portion **34**. A concentration sensor **29D** is provided through a pipe to a gas passageway and the concentration of an absorption substance which is measured by the concentration sensor **29D** is supplied to the main control system **25**. The flow of the gas fed from the blast portion **33** is controlled such that the concentration of the absorption substance which is measured by the concentration sensor **29** is equal to or lower than an allowable concentration.

In the present embodiment, it is desirable that a wafer plane should be coincident with a surface excluding a portion on which a wafer of a wafer holder is to be mounted in order to maintain a direction in which a transmission gas to a surface (wafer plane) of a wafer W to be one direction. When the wafer plane is protruded from the wafer holder, there is a possibility that an air flow in a constant direction might be changed in the peripheral portion of the wafer. Therefore, a dent (a concave portion) in which the wafer is mounted is previously formed in the central portion of the surface of the wafer holder and the wafer is mounted in the dent to cause the wafer plane to be coincident with the surface of the wafer holder.

In the present embodiment, thus, a local gas flow is generated on the optical path of an exposure beam, thereby relieving a reduction in the illuminance on the surface of the wafer W. Accordingly, a work for exchanging a gas by taking in and out the wafer is not required. Consequently, there is an advantage that higher throughput can be obtained. On the other hand, in the present embodiment, it is hard to manage the concentration of the absorption substance by the flow of the outside air with higher precision than that in the first embodiment. In the case in which more importance is attached to the relief of a reduction in the illuminance than an enhancement in the throughput, therefore, it is desirable that the first embodiment should be utilized. It is apparent that the gas flow in FIG. 3 should be obtained by a substance which less absorbs the exposure beam (does not absorb the exposure beam substantially).

It is apparent that a method of relieving the reduction in the illuminance of the exposure beam through the gas flow obtained by a substance having a small absorptivity 25 an also be applied to the reticle chamber **2** (the reticle operating portion **6**) easily. Moreover, the same method can also be applied to the illuminating optical system portion **5** and the projecting optical system PL. In that case, however, it is necessary to employ a double structure for these portions.

Next, a preferred third embodiment of the present invention will be described with reference to FIG. **4**. In FIG. **4**, portions corresponding to those in FIGS. **1** and **2** have the same reference numerals and detailed description thereof will be omitted.

FIG. 4 is a sectional view showing a structure from a projecting optical system PL1 to a wafer stage 23 in a projecting exposure apparatus according to the present embodiment. In FIG. 4, an F_2 laser beam to be a vacuum violet light is used as an exposed light IL. A projecting optical system PL1 comprising a catadioptric system according to the present embodiment is also constituted by a first imaging optical system K1 of a refraction type for forming an intermediate image (a primary image) of the pattern of a reticle R and a second imaging optical system K2 of a catadioptric type for forming a final image of the reticle pattern on a wafer W to be a photosensitive substrate with

a reduced magnification based on the light transmitted from the intermediate image.

The first imaging optical system K1 is constituted by a first lens group G1 having a positive refractive power, an aperture diaphragm S and a second lens group G2 having a positive refractive power which are sequentially provided from the reticle side. The first lens group G1 is constituted by a meniscus lens L31 having a non-spherical convex turned toward the reticle side, a biconvex lens L32 having a non-spherical convex turned toward the reticle side, a meniscus lens L33 having a non-spherical concave turned toward the wafer side, and a meniscus lens L34 having a non-spherical convex turned toward the reticle side which are sequentially provided from the reticle side. Moreover, the second lens group G2 is constituted by a meniscus lens L41 having a non-spherical convex turned toward the reticle side, a biconvex lens L42 having a non-spherical convex turned toward the wafer side, and a meniscus lens L43 having a non-spherical concave turned toward the wafer side which are sequentially provided from the reticle side. Furthermore, a central shielding member SP for shielding a light in the vicinity of an optical axis AX1 is provided in a position shifted from an aperture diaphragm S by a predetermined space in the direction of the optical axis AX1.

On the other hand, the second imaging optical system K2 is constituted by a main mirror M3 including an opening (a light transmitting portion) 61A in a central portion and a reflection plane R3 having a concave turned toward the wafer side and negative refractive force, a lens component L4, and an auxiliary mirror M4 including a reflection plane R4 having an opening 62A in a central portion. The lens component L4 is a negative meniscus lens having a non-spherical concave turned toward the wafer side. More specifically, all optical elements (G1, G2, M3, L4, M4) constituting the projecting optical system PL1 are provided along a single optical axis AX1. Furthermore, the main mirror M3 is provided in the vicinity of a position where the intermediate image is to be formed and the auxiliary mirror M4 is provided in the proximity of the wafer W. In the present embodiment, an exposed light IL (an imaging luminous flux) transmitted from the pattern of the reticle R forms an intermediate image by the first imagining optical system K1 and the imaging luminous flux transmitted from the intermediate image passes through an opening 61A of the main mirror M3 and is reflected by the reflection plane R4 provided on the upper surface of the auxiliary mirror M4 through the lens component L4, and is then reflected by the reflection plane R3 of the main mirror M4 through the lens component L4 and is incident on the wafer W through a lens component L2 and the opening 62A of the auxiliary mirror M4 again.

In the present embodiment, portions from the first imaging optical system K1 to the lens component L4 of the second imaging optical system K2 are enclosed and supported in a single barrel 3B. More specifically, the lenses L31 to L43, the main mirror M3, the lens component L4 and the auxiliary mirror M4 are held in the barrel 3B through a lens frame respectively and a vent for causing a gas to pass therethrough is formed in the lens frame for the optical member of each of the lens L32 to the main mirror M3, and the lens frame of the lens L31 in the uppermost stage, the lens component L4 in the lowermost stage (tip portion) and lens frame 8B and 8C of the auxiliary mirror M4 are sealed respectively.

Moreover, a pipe communicating with a concentration sensor 29C, a pipe 32C communicating with a vacuum pump 30C and a pipe 27C communicating with a gas supply device 26 are connected to the inside of a space including the main mirror M4 of the barrel 3B. By these members, the inside of the space including the main mirror M4 is filled with a purging gas having a high purity.

Moreover, two air feeding pipes 27Ea and 27Eb are provided opposite to the side surface of the barrel 3B between the lens component 4 and the auxiliary mirror M4 with the optical axis AX1 interposed therebetween, and the air feeding pipes 27Ea and 27Eb are connected to the air feeding device 26 through the pipe 27E. Accordingly, a space between the auxiliary mirror M4 and the lens component L4 is sealed excluding the opening 62A. The opening 62A is used as an opening for causing an imaging luminous flux (an exposed light IL) to be an exposure beam to pass therethrough and an opening for causing a purging gas to pass therethrough.

Furthermore, a plurality of exhaust pipes 32Fa and 32Fb are provided in the vicinity of the side face portion of a space between the auxiliary mirror M4 and the wafer W, and are connected to a vacuum pump 30F through a pipe 32F. In the present embodiment, actually, the exhaust pipes 32Fa and 32Fb are provided at regular angular intervals in eight places, for example. The air feeding pipes 27Ea and 27Eb may not only provide in two places but three or more places at almost regular angular intervals.

Furthermore, the wafer W is adsorbed and held on a mounting surface including a concave portion on a wafer holder 22, the wafer holder 22 is fixed to a concave portion on the wafer stage 23, and a surface 23*a* of the wafer stage 23 is provided on almost the level with the surface of the wafer W and that of the wafer holder 22. Consequently, a gas can smoothly flow over the surface of the wafer W.

In the present embodiment, the air is continuously sucked through the pipe 32F and the discharge pipes 32Fa and 32Fb through the vacuum pump 30F simultaneously with the operation for consecutively supplying a purging gas having a high purity from the gas supply device 26 toward the central part between the lens component L4 and the auxiliary mirror M4 in the projecting optical system PL1 through the air feeding pipes 27Ea and 27Eb during exposure. A portion between the lens component L4 and the auxiliary mirror M4 is filled with the purging gas having a high purity and is further pressurized. Consequently, the purging gas having a high purity flows toward the wafer W as shown in an arrow 67 and the absorption substance is caused to flow to an outer peripheral portion together with the purging gas.

In this case, the purging gas having a high purity introduced from the air feeding pipe 27Ea and 27Eb into the space between the lens component L4 and the auxiliary mirror M4 flows in the space toward the center of the opening 62A to be a center of a visual field and then flows in the opening 62A toward the wafer side (in the same direction as the direction of progress of the exposed light IL). The flow of the purging gas in the opening 62A will be referred to as a "down flow". The down-flow purging gas flows to the space between the auxiliary mirror M4 and the wafer W and then flows from the exposing portion (central portion) toward the outside as shown in the arrow 67.

In the process of the flow of the purging gas, the down flow of the purging gas is generated in an opposite direction to a direction of normal diffusion (toward the projecting optical system PL1) of degassing containing an absorption substance generated from the wafer W, particularly, degassing from a photoresist coated on the wafer W. As a result, the degassing from the wafer W is almost prevented from reversely flowing to an upper space of the auxiliary mirror M4 and flows from the center of the visual field to a

peripheral portion to be drawn into the down flow of the purging gas. The gas generated from the wafer W, particularly, a purging gas containing the gas sent from the photoresist coated on the wafer W will be referred to as "a gas containing an absorption substance".

In the present embodiment, thus, it is possible to prevent a transmittance from being reduced due to the adhesion of the gas fed from the wafer W to the optical member on the tip of the projecting optical system PL1 by the down flow of the gas containing an absorption substance. Moreover, the absorption substance contained in the degassing is exhausted so that the evenness of the exposed light IL (imaging luminous flux) can be maintained, the imaging characteristic of the projecting optical system PL1 can be enhanced, and furthermore, the uniformity of the line width of a circuit pattern formed on the wafer W can be increased. In addition, a sufficient amount of the light can be caused to reach the exposing plane of the wafer W and the throughput of the exposing step can be enhanced.

In the present embodiment, furthermore, the bottom surface of the optical member (the auxiliary mirror M4) on the tip of the projecting optical system PL and the bottom surface of the lens frame 8C are flat and are positioned on the same plane. In the lower part, moreover, the upper surface 23*a* of the wafer stage 23, the upper surface of the wafer holder 22 and the exposed plane of the wafer W are positioned on almost the same level with the bottom surface of the auxiliary mirror M4 in parallel therewith. Accordingly, the purging gas can flow in the upper and lower spaces of the auxiliary mirror M4 (the lens frame 8C) very smoothly and the absorption substance can be efficiently discharged toward the outer peripheral portion side.

Moreover, it is desirable that a discharge ratio of a gas (the volume of a gas to be sucked per unit time) in the exhaust pipes 32Fa and 32Fb should be set to be higher than a supply ratio of a gas (the volume of the gas blown our per unit time) in the air feeding pipes 27Ea and 27Eb for the purging gas. Consequently, the atmosphere in the vicinity of the wafer stage 23 (dry air in the present embodiment) is sucked in addition to the gas containing the absorption substance. The flow in the atmosphere is usually turned from the wafer stage 23 in the direction of the exposed region (the central portion of the down flow of the purging gas having a high purity). Consequently, the gas containing an impurity is prevented from flowing from the upper part of the wafer stage 23 to an external space. Consequently, it is possible to reduce a change in a refractive index in the atmosphere in the outer peripheral portion of the wafer stage 23 as much as possible. Consequently, a fluctuation in the optical path for a laser beam of a laser interferometer for measuring the position of the wafer stage 23 is reduced and the positional precision of the wafer stage 23 can be enhanced. Moreover, the measuring precision of the focus position of an autofocus sensor can also be enhanced.

By implementing the flow of the purging gas having a high purity over the wafer stage 23 without disturbing the external atmosphere as in the present embodiment, it is possible to efficiently supply a purging gas having a high purity preponderantly around the exposing portion on the wafer. At the same time, it is possible to more lessen a detection error made by the interferometer or autofocus sensor for positioning the wafer stage 23 through a fluctuation in a refraction index through the mixture of the purging gas having a high purity and the atmosphere around the wafer stage 23.

In the present embodiment, moreover, also in the case in which a space d2 of a working distance portion between the optical member (the auxiliary mirror M4) on the tip of the projecting optical system PL1 and the wafer W is small, the purging gas having a high purity can be supplied in the form of the down flow toward the wafer W.

In each of the embodiments, moreover, a laser interferometer for measuring the position of the reticle stage 21 is provided in the reticle chamber 2 and a laser interferometer for measuring the position of the wafer stage 23 is also provided in the wafer chamber 4 in FIG. 1 or the wafer operating portion 7 in FIG. 3. In this case, it is desirable that the optical path of the laser beam for measurement of the laser interferometer should be covered with a cylinder such as a pipe in order to prevent a fluctuation in the laser beam.

Moreover, it is desirable that a housing (a cylindrical member or the like) constituting portions from the illuminating system chamber 1 to the wafer chamber 4 and a pipe for supplying a nitrogen gas, a helium gas or the like should be formed of a material having a small amount of impurity gasses (degassing), for example, various polymers such as stainless steel, ethylene tetrafluoride, tetrafluoroethylene-terfluoro (alkylvinyl ether) or a tetrafluoroethylene-hexafluoropropene copolymer.

In the absorption substance, attention should be paid to steam, hydrocarbon, halides and the like. It has been known that a large number of substances such as steam are stuck in a large amount onto the surfaces of the housing and the pipe gradually leak into a space in which substitution is carried out by the purging gas, that is, a space including the optical path of an illumination light (hereinafter referred to as an "optical path space") during vacuum exhaust or by the action on the purging gas. Moreover, the absorption substance such as hydrocarbon or a halide is discharged from a material for covering a cable for feeding a power to a driving mechanism (a reticle blind, a stage or the like) present in the optical path space or the like, a sealing material (an O ring or the like), an adhesive or the like. For this reason, after the substitution is once carried out by the purging gas, the concentration of the absorption substance is always monitored. If the concentration of the absorption substance is more than an allowable value, it is preferable that a working for exposing the circuit pattern should be once stopped and the substitution should be carried out by the purging gas again.

More specifically, the concentration (amount) of the absorption substance in each space is always monitored by means of each concentration sensor. When the result of the measurement of at least one concentration sensor is equal to or greater than an allowable value or it is anticipated that the concentration becomes equal to or greater than the allowable value through a main control system 25 based on the result of the measurement of the concentration sensor, the exposing work is automatically stopped. Then, a work for reducing the absorption substance is carried out. When the concentration of the absorption substance is reduced to the allowable value or less, the exposing work is restarted. For this purpose, it is preferable that a concentration managing system should be provided.

Furthermore, it is preferable that a material for covering a cable for supplying a power to a driving mechanism (a reticle blind, a stage or the like) in each housing, a sealing member (an O ring or the like), an adhesive or the like should not be provided in the optical path space if possible or the cable for supplying the power to the driving mechanism in the housing or the like should also be coated with a material having a small amount of impurity gases (degassing), thereby controlling the amount of the absorption substance to be generated.

Furthermore, it has been known that the amount of adsorption of a gas such as steam which is discharged from the surface of the housing or the pipe is greatly varied depending on the state of the material of the housing or the pipe. For this reason, it is desirable that the amount of adsorption of the steam or the like should be reduced as much as possible. For example, if the surface area of a structural material is larger, the number of molecules of the absorption substance to be adsorbed is increased. Therefore, the optical path space is preferably designed so as not to have a fine structure such that the surface area is reduced. For the same reason, moreover, it is preferable that polishing such as mechanical polishing, electrolytic polishing, buff polishing, chemical polishing or GBB (Glass Bead Blasting) should be carried out to reduce the surface roughness of the housing or the pipe. In this case, it is preferable that the surface roughness represented by a center line mean roughness (Ra) should be 0.2 μm or less.

Moreover, it is preferable that pure titanium, Ti-6A1-4V, SUS-304, 403, 410 and C3604 should be used as a material for forming a tube member (including a barrel).

Furthermore, it is desirable that a flororesin coat, NiP, NiP-Ni and BCr should be used as a surface finishing material of the tube member (including a barrel).

Preferably, these treatments are carried out, and furthermore, the surfaces of the housing and the pipe are cleaned through ultrasonic cleaning, spraying of a fluid such as dry air, vacuum-heating degassing (baking) or the like before the exposure of the circuit pattern and the substitution using the purging gas, thereby reducing the amount of degassing from the surfaces of the housing and the pipe. It is apparent that the effects of the present invention can be further obtained from these contrivances.

While a gas rarely absorbing the exposure beam is supplied to the illuminating system chamber 1 to the wafer chamber 4 (or the lower portion of the cover 4A) in the present embodiment, their partial optical paths may be used in a pressure reducing stage. Consequently, even if the exposure beam has a shorter wavelength, a high illuminance can be obtained on the wafer.

Although the illuminating optical system 5 is accommodated in one illuminating system chamber 1 in the present embodiment, the inside of the illuminating system chamber 1 may be divided into a plurality of partial optical paths and an optical element constituting the illuminating optical system 5 may be provided in the partial optical path. In this case, it is desirable that the absorption substance or the concentration of the purging gas should be managed for each partial optical path.

It is apparent that the present invention can be applied to a projecting exposure apparatus of a full field exposure type (stepper type) and an exposure apparatus using a proximity method as well as a projecting exposure apparatus of a scanning and exposing type.

Moreover, the present invention can also be applied to the case in which an extreme ultraviolet light (EUV light) having a wavelength of approximately 100 nm or less such as soft X-rays is used as an exposure beam, and similarly, to an electron beam transfer apparatus using an electron beam as the exposure beam. In the case in which the EUV light or the electron beam is to be used, the optical path of the exposure beam is to be vacuum. Almost all materials in the outside air become the absorption substances, and the mechanism of the whole apparatus can be simplified by managing the concentrations of the absorption substances every partial optical path of the exposure beam.

Moreover, the projecting exposure apparatus according to the embodiments adjusts the illuminating optical system and the projecting optical system and couples and incorporates each component electrically, mechanically or optically. In this case, it is desirable that the work should be carried out in a clean room in which a temperature is managed. The wafer W thus exposed as described above is subjected to a developing step, a pattern forming step, a bonding step and the like so that a device such as a semiconductor device can be manufactured.

The present invention is not limited to the above-mentioned embodiments, and the invention may, as a matter of course, be embodied in various forms without departing from the gist of the present invention. Furthermore, the entire disclose of Japanese Patent Application 11-34897 filed on Feb. 12, 1999 including description, claims, drawings and abstract are incorporated herein by reference in its entirety.

INDUSTRIAL APPLICABILITY

According to the first, third or fourth exposure method of the present invention, it is possible to increase the illuminance of the exposure beam on the substrate to be a transfer object.

According to the second exposure method, moreover, in the case in which an exposure beam capable of being easily absorbed by various materials such as a vacuum ultraviolet light is to be used, it is possible to increase the illuminance of the exposure beam on the substrate to be the transfer object without complicating the mechanism of the whole apparatus or greatly increasing the running cost.

According to the present invention, the absorption substance can be relieved or eliminated such that the concentration is equal to or lower than an allowable concentration set for each portion and a reduction in the illuminance for each portion can be managed. Consequently, a circuit pattern can be stuck more reliably, and furthermore, the throughput of the process for manufacturing an electronic device or the like can be enhanced. By independently managing the concentration (amount) of the absorption substance in each portion, moreover, each portion can be designed more easily, the manufacturing cost of the apparatus can be reduced and the maintenance property of each portion can be enhanced.

Furthermore, according to the exposure apparatus according to the present invention, the exposure method according to the present invention can be carried out, and according to the device manufacturing method according to the present invention, there is an advantage of capable of mass-producing various devices with high throughput.

The invention claimed is:

1. An exposure method which transfers a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, comprising:

dividing an optical path of the exposure beam from the exposure light source to the substrate into a plurality of partial optical paths having lengths different from one another;

respectively setting allowable concentrations of absorption substance, which absorbs the exposure beam, in the plurality of partial optical paths depending on a length of each of the partial optical paths; and

managing concentrations of the absorption substance in the plurality of the partial optical paths independently of each other in order for the concentrations of the absorption substance in the plurality of the partial optical paths to be respectively equal to or lower than the set allowable concentrations of the absorption substance in the plurality of the partial optical paths.

2. An exposure method as recited in claim 1, wherein a gas which is transparent with respect to the exposure beam is supplied to at least a part of the plurality of the partial optical paths for the exposure beam.

3. An exposure method as recited in claim 1, wherein the exposure beam is a light in a vacuum ultraviolet region, and the absorption substance is oxygen, water or carbon dioxide.

4. A method of manufacturing a device, comprising transferring a predetermined pattern onto the substrate in a state that an illuminance of an exposure beam is managed on the substrate by using the exposure method as recited in claim 1.

5. An exposure method as recited in claim 1, wherein the set allowable concentrations of the absorption substance are different from each other for every partial optical path.

6. An exposure method as recited in claim 5, wherein when the concentration of the absorption substance in at least one of the plurality of the partial optical paths is equal to or more than the set allowable concentration thereof, the transfer operation is stopped.

7. An exposure method as recited in claim 1, wherein gases which are transparent with respect to the exposure beam are respectively supplied to the plurality of the partial optical paths, and kinds of the gases are different from one another depending on lengths of the partial optical paths.

8. An exposure method as recited in claim 7, wherein a helium gas is supplied to a space of the partial optical path having a long length and a nitrogen gas is supplied to a space of the partial optical path having a short length.

9. An exposure method as recited in claim 1, wherein the optical path of the exposure beam includes an optical path of an illuminating system which illuminates a mask on which the predetermined pattern is formed, an optical path of a projecting optical system which transfers the predetermined pattern onto the substrate, an optical path between the illuminating system and the projecting optical system and an optical path between the projecting optical system and the substrate.

10. An exposure method as recited in claim 9, wherein the optical path between the illuminating system and the projecting optical system is shorter than the optical path of the illuminating system.

11. An exposure method as recited in claim 10, wherein outside air flows into the optical path between the illuminating system and the projecting optical system more easily than the optical path of the illuminating system.

12. An exposure method as recited in claim 9, wherein the optical path between the projecting optical system and the substrate is shorter than the optical path of the projecting optical system.

13. An exposure method as recited in claim 12, wherein outside air flows into the optical path between the projecting optical system and the substrate more easily than the optical path of the projecting optical system.

14. An exposure method as recited in claim 1, wherein the allowable concentrations of the absorption substance is set in order for allowable absorptances of the exposure beam in the plurality of the partial optical paths to be constant.

15. An exposure method as recited in claim 1, wherein a gas which is transparent with respect to the exposure beam is supplied to each of the plurality of the partial optical paths, and the concentrations of the absorption substance are managed by exhausting the absorption substance outside the partial optical paths together with the transparent gas.

16. An exposure method which irradiates an exposure beam from an exposure light source onto a mask through an illumination system and transfers a patter of the mask onto a substrate through a projecting optical system, comprising:

dividing an optical path of the exposure beam from the exposure light source to the substrate into a plurality of partial optical paths including an illumination system portion in the illumination system, a mask operating portion provided around the mask, a projecting optical system portion including at least a part of the projecting optical system and a substrate operating portion including an upper portion of the substrate;

respectively setting allowable concentrations of absorption substance, which absorbs the exposure beam, in the plurality of the partial optical paths depending on a length of each of the partial optical paths; and

managing concentrations of the absorption substance in the plurality of the partial optical paths independently of each other in order for the concentrations of the absorption substance in the plurality of the partial optical paths to be respectively equal to or lower than the set allowable concentrations of the absorption substance in the plurality of the partial optical paths.

17. An exposure method as recited in claim 16, wherein there is provided a delivery space which delivers the mask from a mask library to the mask operating portion, and in the delivery space, a concentration of the absorption substance is managed independently of the concentrations of the absorption substance of the partial optical paths including the mask operating portion.

18. An exposure method as recited in claim 17, wherein in the space of the mask library, a concentration of the absorption substance is managed independently from that of the delivery space.

19. An exposure method as recited in claim 16, wherein a gas which is transparent with respect to the exposure beam is supplied from the projecting optical system side to between the projecting optical system and the substrate, and the gas is discharged from the substrate side.

20. An exposure method as recited in claim 19, wherein a ratio of the supply of the gas is smaller than that of discharge of the gas.

21. An exposure method which transfers a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, comprising:

dividing an optical path of the exposure beam from the exposure light source to the substrate into a plurality of partial optical paths having lengths different from one another;

respectively setting allowable absorptances of the exposure beam depending on a length of each of the partial optical paths; and

managing concentrations of an absorption substance, which absorbs the exposure beam, in the plurality of the partial optical paths independently of each other in order for absorbance of the exposure beam in the plurality of the partial optical paths to be the set allowable absorptances of the exposure beam in the plurality of the partial optical paths.

22. An exposure method which transfers a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, comprising:

dividing an optical path of the exposure beam from the exposure light source to the substrate into a plurality of partial optical paths, said plurality of partial optical paths respectively including absorption substance therein, which absorbs the exposure beam;

respectively supplying a gas which is transparent with respect to the exposure beam to each of the plurality of the partial optical paths;

respectively setting concentrations of the gas in the plurality of the partial optical paths depending on a length of each of the partial optical paths; and

managing concentrations of the absorption substance in the plurality of the partial optical paths independently of each other in order for concentrations of the gas in the plurality of the partial optical paths to be set concentrations of the gas in the plurality of the partial optical paths.

23. An exposure method as recited in claim 22, wherein the optical path of the exposure beam includes an optical path of an illuminating system which illuminates a mask on which the predetermined pattern is formed, an optical path of a projecting optical system which transfers the predetermined pattern onto the substrate, an optical path between the illuminating system and the projecting optical system and an optical path between the projecting optical system and the substrate.

24. An exposure method as recited in claim 23, wherein the optical path between the illuminating system and the projecting optical system is shorter than the optical path of the illuminating system.

25. An exposure method as recited in claim 24, wherein outside air flows into the optical path between the illuminating system and the projecting optical system more easily than the optical path of the illuminating system.

26. An exposure method as recited in claim 23, wherein the optical path between the projecting optical system and the substrate is shorter than the optical path of the projecting optical system.

27. An exposure method as recited in claim 26, wherein outside air flows into the optical path between the projecting optical system and the substrate more easily than the optical path of the projecting optical system.

28. An exposure method as recited in claim 22, wherein the concentrations of the absorption substance are managed by exhausting the absorption substance outside the partial optical paths together with the transparent gas.

29. An exposure apparatus which transfers a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, comprising:

a plurality of chambers which divide an optical path of the exposure beam from the exposure light source to the substrate into a plurality of partial optical paths having lengths different from one another and which covers the plurality of the partial optical paths to substantially isolate the plurality of the partial optical paths from outside air, respectively; and

a controller which is connected to the plurality of chambers and which manages concentrations of an absorption substance, which absorbs the exposure beam, in the plurality of the chambers independently of each other in order for concentrations of the absorption substance in the plurality of the partial optical paths to be respectively equal to or lower than set allowable concentrations of the absorption substance in the plurality of the partial optical paths.

30. An exposure apparatus as recited in claim 29, further comprising:

concentration sensors which are disposed in the plurality of the chambers and which measure the concentrations of the absorption substance in the plurality of the chambers; and

an eliminator which is connected to the controller and which eliminates the absorption substance in the plurality of the chambers according to the result of measurement of the concentration sensors.

31. An exposure apparatus as recited in claim 30, wherein the controller stops the transfer operation when the concentration of the absorption substance in at least one of the plurality of the chambers is equal to or higher than a predetermined allowable concentration.

32. An exposure apparatus as recited in claim 29, wherein:

the predetermined pattern is a pattern formed on a mask;

the pattern of the mask is transferred onto the substrate through a projecting optical system; and

the plurality of the chambers include a first chamber which covers an illuminating system portion in an illuminating system for the exposure beam, a second chamber which covers a mask operating portion around the mask, a third chamber which covers a projecting optical system portion including at least a part of the projecting optical system, and a fourth chamber which covers a substrate operating portion including an upper portion of the substrate.

33. An exposure apparatus as recited in claim 29, further comprising a supply device which is connected to the plurality of the chambers and which respectively supplies gases which are transparent with respect to the exposure beam to the plurality of the partial optical paths.

34. An exposure apparatus as recited in claim 29, further comprising a mask library which accommodates a mask, wherein the controller manages a concentration of an absorption substance in a delivery space between the mask library and the second chamber.

35. An exposure apparatus as recited in claim 34, wherein the controller manages a concentration of an absorption substance in a space of the mask library.

36. An exposure apparatus as recited in claim 29, wherein the controller sets allowable concentrations of the absorption substance in order for allowable absorptances of the exposure beam in the plurality of the partial optical paths to be constant.

37. An exposure apparatus which transfers a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, comprising:

a plurality of chambers which divide an optical path of the exposure beam from the exposure light source to the substrate into a plurality of partial optical paths having lengths different from one another and which cover the plurality of partial optical paths to substantially isolate the plurality of the partial optical paths from outside air, respectively;

a supply device which is connected to the plurality of the chambers and which supplies a gas which is transparent with respect to the exposure beam to each of the plurality of the chambers; and

a controller which is connected to the plurality of the chambers and which managed concentrations of absorption substance, which absorbs the exposure beam, in the plurality of the chambers independently of each other in order for concentrations of the gas in the plurality of the partial optical paths to be concentrations of the gas in the plurality of the partial optical paths which have been set depending on a length of each of the partial optical paths.

38. An exposure apparatus as recited in claim 37, further comprising:

concentration sensors which are disposed in the plurality of chambers and which measure the concentrations of the absorption substance in the chambers, and

an eliminator which is connected to the controller and which eliminates the absorption substance in the plu-

rality of the chambers according to the measurement result of the concentration sensors.

39. An exposure apparatus as recited in claim 37, wherein:

the predetermined pattern is a pattern formed on a mask;

a pattern of the mask is transferred onto the substrate through a projecting optical system; and

the plurality of the chambers include a first chamber which covers an illuminating system portion in an illuminating system for the exposure beam, a second chamber which covers a mask operating portion around the mask, a third chamber which covers a projecting optical system portion including at least a part of the projecting optical system, and a fourth chamber which covers a substrate operating portion including an upper portion of the substrate.

40. An exposure apparatus as recited in claim 37, wherein the controller stops the transfer operation when the concentrations of the absorption substance included in the transparent gas becomes equal to or larger than a predetermined value in at least one chamber of the polarity of the chambers.

41. An exposure method, comprising transferring a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, wherein:

an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths having lengths different from one another;

allowable concentrations of absorption substance, which absorbs the exposure beam, in the plurality of the partial optical paths are respectively set depending on a length of each of the partial optical paths; and

concentrations of the absorption substance in the plurality of the partial optical paths are managed independently of each other, in order for the concentrations of the absorption substance in the plurality of the partial optical paths to be respectively equal to or lower than the set allowable concentrations of the absorption substance in the plurality of the partial optical paths.

42. An exposure method, comprising irradiating an exposure beam from an exposure light source onto a mask through an illumination system so as to transfer a pattern of the mask onto a substrate through a projecting optical system, wherein:

an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths including an illumination system portion in the illumination system, a mask operating portion provided around the mask, a projecting optical system portion including at least a part of the projecting optical system and a substrate operating portion including an upper portion of the substrate;

allowable concentrations of absorption substance, which absorbs the exposure beam, in the plurality of the partial optical paths are respectively set depending on a length of each of the partial optical paths; and

concentrations of the absorption substance in the plurality of the partial optical paths are managed independently of each other in order for the concentrations of the absorption substance in the plurality of the partial optical paths to be respectively equal to or lower than the set allowable concentrations of the absorption substance in the plurality of the partial optical paths.

43. An exposure method, comprising transferring a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, wherein:

an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths having lengths different from one another;

allowable absorptances of the exposure beam are respectively set depending on a length of each of the partial optical paths; and

concentrations of an absorption substance, which absorbs the exposure beam, in the plurality of the partial optical paths are managed independently of each other in order for absorptances of the exposure beam in the plurality of the partial optical paths to be the set allowable absorptances of the exposure beam in the plurality of the partial optical paths.

44. An exposure method, comprising transferring a predetermined pattern onto a substrate by using an exposure beam from an exposure light source, wherein:

an optical path of the exposure beam from the exposure light source to the substrate is divided into a plurality of partial optical paths, said plurality of partial optical paths respectively including absorption substance therein, which absorbs the exposure beam;

a gas which is transparent with respect to the exposure beam is supplied to each of the plurality of the partial optical paths;

concentrations of the gas in the plurality of the partial optical paths are respectively set depending on a length of each of the partial optical paths; and

concentrations of the absorption substance in the plurality of the partial optical paths are managed independently of each other in order for concentrations of the gas in the plurality of the partial optical paths to be the set concentrations of the gas in the plurality of the partial optical paths.

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